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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ENVIRONMENTAL STATEMENT

FOR

PIONEER F/G PROGRAM

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FINAL STATEMENT

JAN 1972

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for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF SPACE SCIENCE
PIONEER F/G PROGRAM

PROGRAM OBJECTIVES AND DESCRIPTION

The primary objective of the Pioneer F/G Program is to conduct exploratory investigations beyond the orbit of Mars of the interplanetary medium, the nature of the Asteroid Belt and the environmental and atmospheric characteristics of the planet Jupiter. The secondary objective is to advance the technology and operational capability for long duration flights to the outer planets.

The Pioneer Program is sponsored by the Planetary Programs Office of the National Aeronautics and Space Administration (NASA) Office of Space Science and Applications (OSSA) with overall project management responsibility assigned to the NASA Ames Research Center.

The launch vehicle for the Pioneer F/G Mission consists of an Atlas first stage, Centaur second stage, and TE-364-4 third stage. A direct-ascent powered flight path will be followed to place the space flight system into an interplanetary trajectory to Jupiter. The space flight system comprises the spacecraft, eleven scientific instruments and four SNAP-19 type radioisotope thermoelectric generators (RTG's) used to supply electrical power to the spacecraft and instruments.

The following launches are planned during the 1972 and 1973 Jovian opportunities:

Pioneer F - Late February or early March, 1972

Pioneer G - April, 1973.

ASPECTS OF THE PROGRAM WHICH MAY AFFECT ENVIRONMENTAL QUALITY

Aspects of the Pioneer F and G launches which may affect environmental quality will be discussed in two areas: those related to the launch vehicle and those related to the spacecraft. In turn, these are subdivided to consider: (1) a normal, successful launch; and (2) abnormal launches, aborted flights, or accidents.

Launch Vehicle

Activities of concern in providing the launch vehicles for the Pioneer F and G missions because of possible environment effects are as follows:

- Launch Vehicle Manufacture
- Launch Vehicle and Component Testing
- Launch Operations.

Possible environmental effects which might result from these activities include:

- Degradation of air quality
- Degradation of water quality
- Land or ocean impact of launch vehicle stages and structures
- Noise.

The major activities are concentrated in, but not restricted to, Southern California and Florida.

Description of the Launch Vehicle and Near-Earth Trajectory

The Pioneer F and G spacecraft will be launched from the Cape Kennedy Air Force Station Launch Complex 36 by the Atlas/Centaur/TE-364-4 launch vehicle. General Dynamics Convair Aerospace Division manufactures the Atlas and Centaur stages. The spin stabilized third stage is provided by the McDonnell Douglas Astronautics Corporation. Vehicle project management is assigned to the NASA Lewis Research Center.

The Atlas is powered by three Rocketdyne engines burning liquid oxygen and RP-1, a kerosene -type fuel. At sea level the two booster engines develop 350,000 lb thrust and the sustainer engine 60,000 lb thrust. The booster engines and associated hardware are jettisoned when the vehicle acceleration reaches approximately 5.7g.

The Centaur stage uses two Pratt and Whitney RL10A-3-3 engines burning liquid oxygen and liquid hydrogen. Each engine is rated at 15,000 lb thrust in vacuum.

The third stage uses the Thiokol TE-364-4 solid propellant motor manufactured by the Thiokol Chemical Corporation, which develops an average vacuum thrust of 14,810 lb. The TE-364-4 propellant consists of ammonium perchlorate and aluminum in a rubbery binder made from carboxy terminated polybutadiene. Prior to separation from the Centaur, the third stage is spun by eight small solid propellant rocket motors attached to a spin bearing.

The products of combustion exhausted from the rocket nozzles may include compounds and molecular fragments which are not stable at ambient conditions, or which may react with the ambient atmosphere. Major chemical species emitted by the Atlas engine which are potentially stable at ambient temperatures are:

Water

Carbon Dioxide

Carbon Monoxide

Hydrogen.

Major chemical species emitted by the Centaur engines would include only water and hydrogen.

Major chemical species emitted by the TE-364-4 are:

Water

Carbon Dioxide

Carbon Monoxide

Hydrogen Chloride

Nitrogen

Hydrogen

Aluminum Oxide.

Of these constituents, carbon monoxide (CO), and hydrogen chloride (HCl), are generally recognized as toxicants. In the upper atmosphere, water (H_2O), and carbon dioxide (CO_2), may be considered as potentially undesirable materials due to their low natural concentration and their possible influence on the Earth's heat balance and on the ozone and electron concentration.

Table 1 is a brief inventory of the propellants and other fluids and gases contained in the launch vehicle. Propellants jettisoned with the Centaur consist of both trapped propellants (about 410 lb) and flight performance reserves and propellant margin which may or may not be burned.

Figure 1 indicates the envelope of possible trajectories (the relationships between ground range and altitude) for the Pioneer F mission.(1) Also shown are the separation points of jettisoned hardware (spent stages, shrouds, etc.). The variation in the flight paths is needed to accommodate launch time variations.

A map indicating the impact points and dispersion ellipses of jettisoned structures for the Pioneer F mission is shown in Figure 2.(2) As indicated, the azimuth angle for the Pioneer F launch, which will be a planar trajectory, will be between 94.5 and 110.1°.

Figure 3 shows plots of envelope limits of instantaneous impact points for the Pioneer F and Pioneer G vehicles.(2,3)

Pioneer G will be launched on a fixed azimuth of 108° with a yaw maneuver to achieve the desired declination. The most southerly impact point trace is indicated on Figure 3. Impact point liftoff will occur within the liftoff envelope indicated.

At conditions corresponding to the larger impact ranges, the quantity of propellant remaining in the vehicle is small, and the reentry of an intact stage is unlikely. It should also be noted that as the vehicle approaches orbiting velocities, the instantaneous impact point sweeps down range at extremely high speeds.

In a normal launch, the exhaust products are distributed along the vehicle trajectory. Due to the acceleration of the vehicle, and the staging process, the quantities emitted per unit length of trajectory are greatest at ground level and decrease continuously. In the event of a vehicle failure in flight, the vehicle destruct system is designed to rupture the propellant tanks and release all remaining propellants, which ignite and burn.

The liquid propellant rocket engines used in the Atlas/Centaur are subjected to an acceptance firing at the manufacturer's facilities. The Rocketdyne test site is in the Santa Susana Mts. in Ventura County,

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(1) "Pioneer F AEC Safety Study. Phase 1. Launch Vehicle Hardware, Launch Complex, and Trajectory Data", General Dynamics Convair Aerospace Division, Report Number GDC-BTD 70-010, Contract NAS3-11817, July 1, 1970.

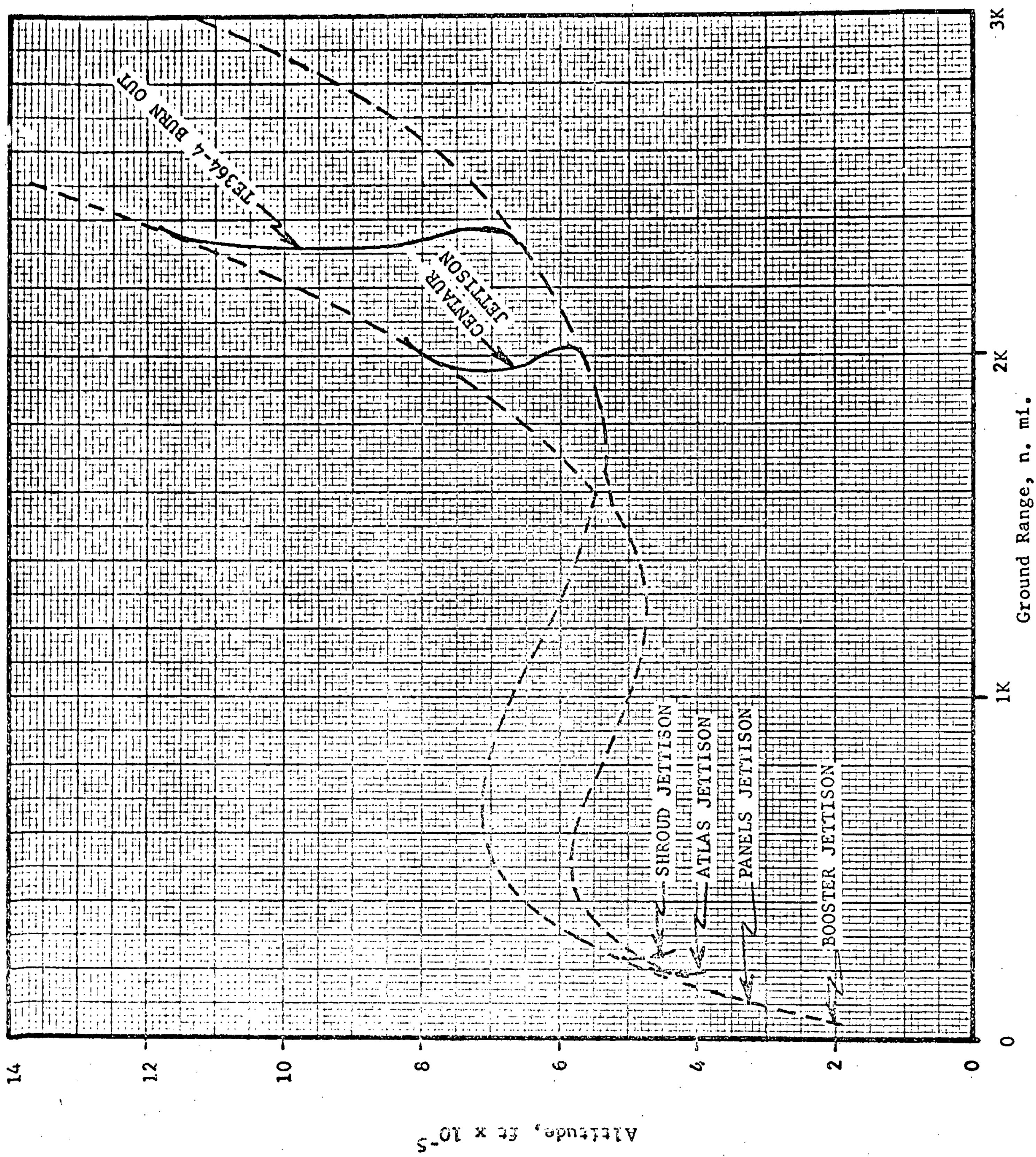
(2) "Pioneer F Launch Vehicle Trajectory Characteristics, Atlas/Centaur AC-27", Report No. GDC-BKM 70-026, Convair Aerospace Division of General Dynamics, Contract NAS3-13504, October, 1970.

(3) Information supplied by J. Nieberding, NASA Lewis Research Center, November 10, 1971.

TABLE 1. INVENTORY OF FLUIDS AND GASES FOR THE PIONEER F/G LAUNCH VEHICLES

	Mass* (lb)	
<u>Atlas</u>		
Propellants Tanked	274,327	
Liquid Oxygen		188,687
RP-1		85,402
Lube Oil		238
Jettisoned with Booster	1,170	
Liquid Oxygen		554
RP-1		487
Lube Oil		41
He		88
Jettisoned with Sustainer	1,327	
Liquid Oxygen		407
Gaseous O_2, N_2 and He		487
RP-1		417
Lube Oil		16
<u>Centaur</u>		
Propellants Tanked	30,725	
Liquid Oxygen		25,447
Liquid Hydrogen		5,278
Propellants Vented	312	
Liquid Oxygen		180
Liquid Hydrogen		132
Jettisoned with Centaur	780	
Liquid Oxygen		560
Liquid Hydrogen		220
<u>TE-364-4</u>		
Propellant Expended		2,300
Other Materials Expended		18

* Masses are for Pioneer F. Masses for Pioneer G do not differ in any significant way.


TE364-4 BURN OUT
CENTAUR JETTISON
SHROUD JETTISON
ATLAS JETTISON
PANELS JETTISON
BOOSTER JETTISON
0
1K
2K
3K
Ground Range, n. mi.
0
2
4
6
8
10
12
14
Altitude, ft x 10^-5

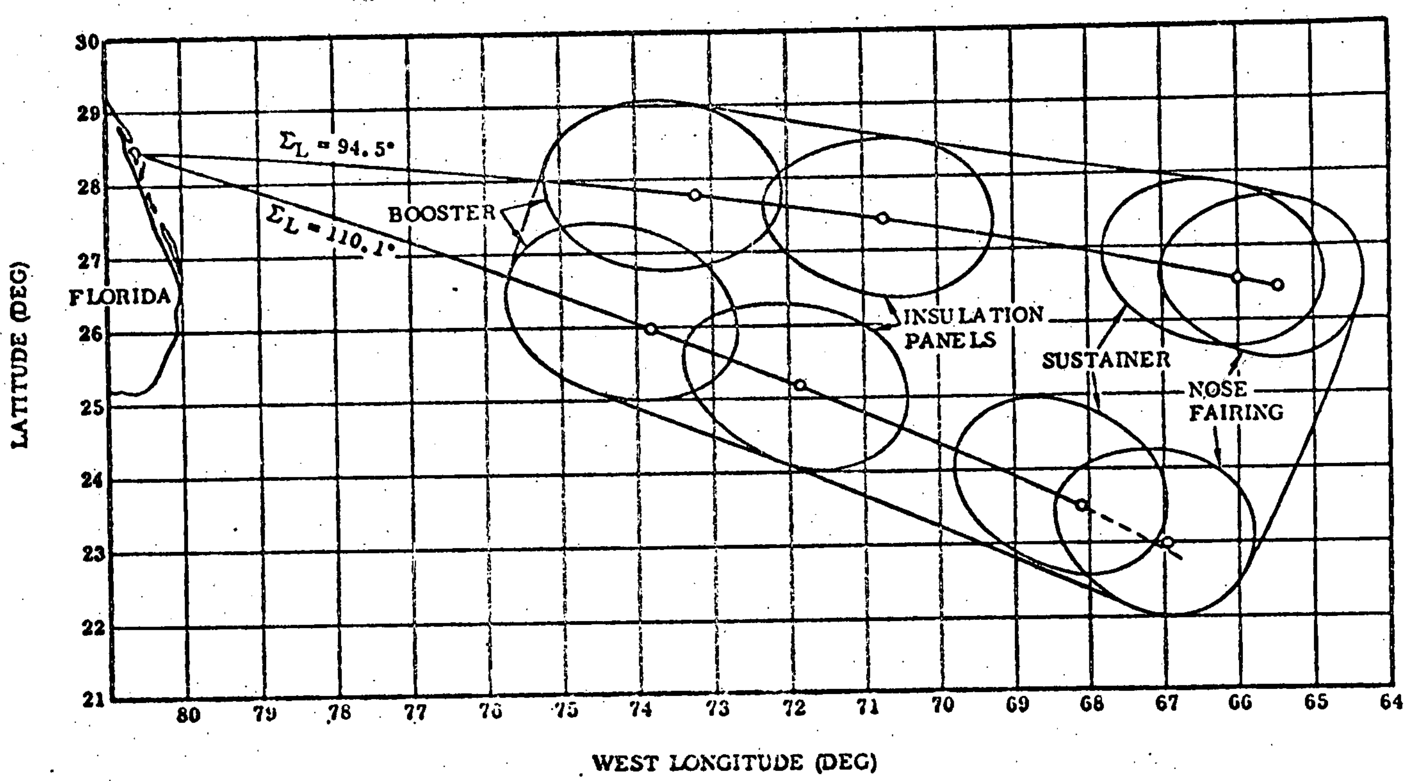


FIGURE 2. ENVELOPE OF IMPACT POINTS OF JETTISONED STRUCTURES FOR THE PIONEER F MISSION

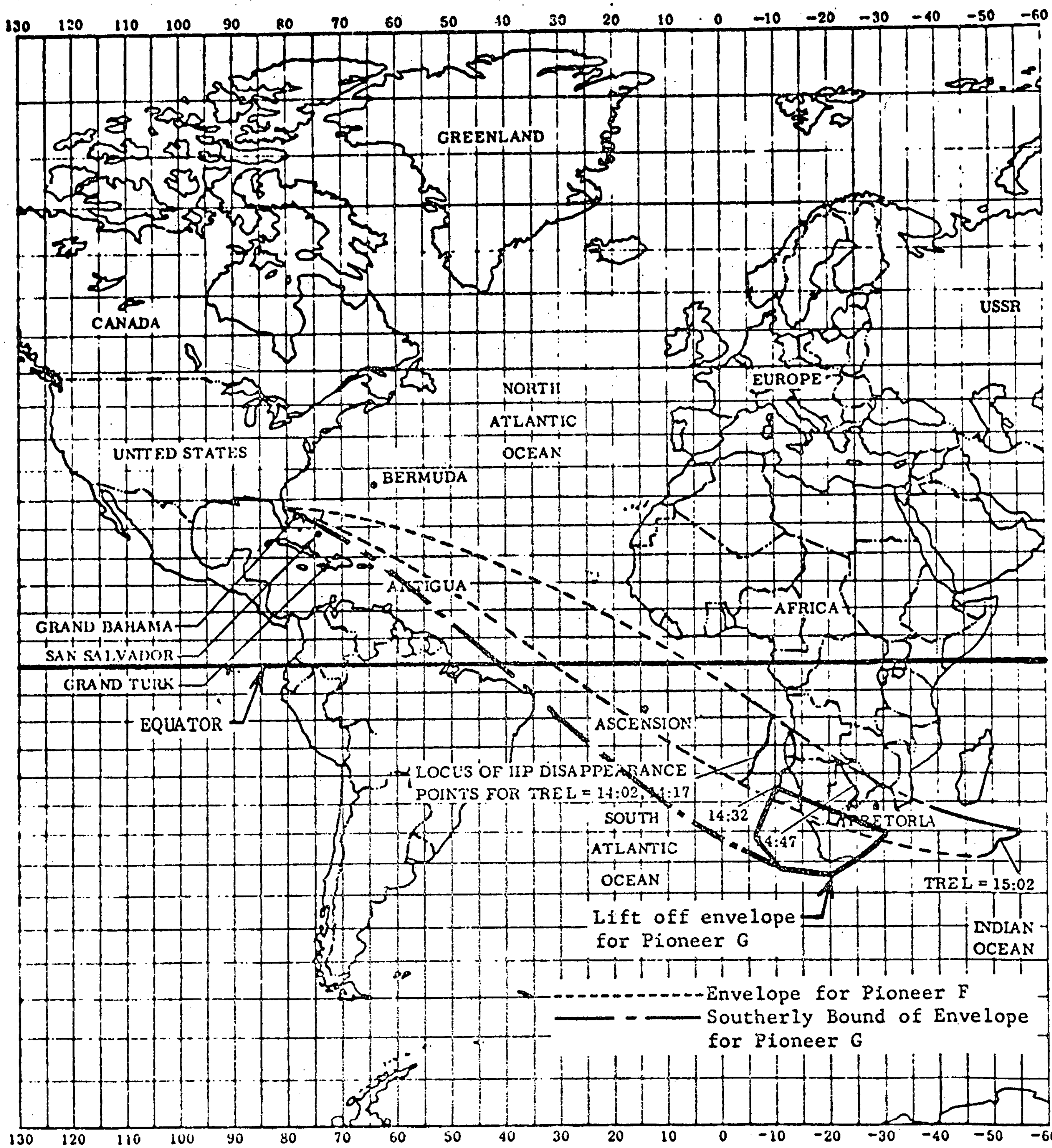


FIGURE 3. ENVELOPE OF INSTANTANEOUS IMPACT POINT TRACES FOR THE PIONEER F AND G MISSIONS

California. Test frequency and propellant consumption are currently as follows:[1]

Engine	Propellant Flow Rate (lb/sec)	Maximum Test Duration (sec)	Test Frequency (times/month)
Atlas Booster	1,445	43	2
Atlas Sustainer	286	135	2

The Centaur engine is tested at a 7,000 acre facility located 16 miles northwest of Palm Beach Gardens, Florida.[2] Approximately two engines are tested per month, with a maximum total firing duration of 1,000 sec per engine.

Normal Launches and Engine Tests

Normal launches and engine tests required for the Pioneer F and G missions may have minor transient adverse effects on environmental quality. The extent of these effects are discussed in the following paragraphs.

Effects on Air Quality. It is convenient to specify different regions of the atmosphere into which the rocket-engine combustion products will be emitted. Each of these regions or layers has a characteristic thermal and wind structure which, in turn, have major influence on the dispersion of these gaseous materials. The characteristics of these layers are summarized in Table 2, which is based upon data from References 3 and 4.

The combustion products for the Atlas/Centaur/TE-364-4 launch vehicle have been listed previously. Table 3 lists the combustion products of concern emitted into selected atmospheric layers by the Atlas/Centaur/TE-364-

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(1) Information provided by H. Weiss, Rocketdyne, Canoga Park, California, November 6, 1971.

(2) Information provided by R. H. Anschutz, Pratt and Whitney Aircraft, West Palm Beach, Florida, November 9, 1971.

(3) R. A. Craig, "The Upper Atmosphere--Meteorology and Physics", Academic Press, New York, 1965.

(4) S. L. Valley (Editor), "Handbook of Geophysics and Space Environments", Air Force Cambridge Research Laboratories, Office of Aerospace Research, 1965.

TABLE 2. DISPERSION CHARACTERISTICS WITHIN SELECTED ATMOSPHERIC LAYERS

Atmospheric Layer; Altitude Range	Temperature Structure	Wind Structure	Characteristic Mixing Rate
Below nocturnal inversion 0-500 m	Increase with height	Very light or calm	Very Poor
Below subsidence inversion 0-1500 m	Decrease with height to inversion base	Variable	Generally fair to inversion base
Troposphere 0.5-20 km	Decrease with height	Variable; increase with height	Generally very good
Stratosphere 20-67 km	Isothermal or increase with height	Tends to vary seasonally	Poor to fair
Mesosphere-Thermosphere Above 67 km	Decrease with height	Varies seasonally	Good

TABLE 3. QUANTITIES OF COMBUSTION PRODUCTS OF CONCERN EMITTED INTO SELECTED ATMOSPHERIC LAYERS BY THE ATLAS/CENTAUR/TE-364-4 LAUNCH VEHICLE

Atmospheric Layer	Altitude Range	Combustion Product	Total Quantity Emitted, pounds
Nocturnal Inversion	0-500 m	CO	13,900
Subsidence Inversion	0-1500 m	CO	22,100
Troposphere	0.5-20 km	CO	53,600
Stratosphere	20-67 km	CO	38,600
		H_2O	25,200
Mesosphere-Thermosphere	Above 67 km	CO	10,500
		CO_2	7,500
		H_2O	34,900
		HCl	485

Using the method developed by GCA(1), the ground level concentration of CO due to an Atlas/Centaur launch has been estimated for realistic adverse meteorological conditions. The estimated peak concentration ranges from as much as 20 parts per million (ppm) within 100 meters of the launch pad to less than 5 ppm at a distance of 10 kilometers. These are within the air quality standards presently adopted; moreover, they would be highly transient since they are estimated peak concentrations.

In-flight emissions at higher altitudes will not result in detectable ground level concentrations. Emissions into the upper troposphere are dispersed rapidly by turbulent mixing and wind shear. In the lower stratosphere, mixing is very poor; however, any material transported downward across the tropopause is then dispersed very rapidly.

High altitude emissions of carbon dioxide and water may have some influence on the heat balance of the Earth through their radiative properties. However, at 25 km altitude, the exhaust cloud will be diluted to ambient background concentrations of both CO_2 and H_2O by the time it expands to one square kilometer. Some, or all, of the HCl from the TE-364-4 motor will be emitted in the F regions (150 km to 300-400 km). Calculations based on a worst case assumption indicate that the HCl emitted by the TE-364-4 motor would decrease the global ionization level in the F regions by less than 0.03%. The natural ionization level regularly fluctuates by a factor of about 1.6. No persistent or widespread effects on the ionization level or radio propagation appear to have resulted from previous solid propellant motor firings at these altitudes, and none are expected to result from the Pioneer F/G missions.

Engine tests differ from launches in that all of the propellant used is consumed at ground level. However, the high temperature of the exhaust gases causes them to rise in a buoyant plume. The downwind concentrations of the exhaust gases are dependent on the height of this buoyant rise, and any elevation contributed by other factors.

The Rocketdyne engine test site in the Santa Susana Mountains in Ventura County, California, is at an elevation of 1900 ft. The nearest neightbor is about 2-1/2 miles distant at an elevation of 900 ft.(2) Engine test procedures are coordinated with both the Ventura County and Los Angeles Air Pollution Control Districts. Appropriate meteorological predictions and projections are used to select the test date and time. Sound levels at the facility boundary do not exceed 95 db under the worst conditions.

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(1) R. K. Dumbould, J. K. Bjorklund, H. E. Cramer, and F. A. Record, "Handbook for Estimating Toxic Fuel Hazards", NASA CR-61326, April, 1970.

(2) Information obtained from H. Weiss, Rocketdyne, Canoga Park, California, November 6, 1971.

Calculations and observations show that the exhaust products from engine tests rise to an altitude of 2500 ft under the worst meteorological conditions. Calculations based on this source height show insignificant CO concentrations at ground level, to the satisfaction of both of the above mentioned Air Pollution Control Districts.

In ground tests, the Centaur (RL-10) engine is exhausted into a supersonic diffuser, a cooler, and a steam jet ejector, with the final exhaust being vertically upward.(1) The steam flow to the ejector greatly exceeds the flow from the engine. No specific state laws concerning air pollution appear to be applicable to the test operations because only water vapor with a small amount of hydrogen is exhausted. These operations are in compliance with the 1970 Federal Occupational Safety and Health Act.

No prelaunch firing tests are performed on the TE-364-4 solid propellant rocket motor.

Emissions of exhaust products from the Atlas/Centaur/TE-364-4 are insignificant when compared with emissions from other sources, as shown in Table 4.

Effects of Noise. The major source of noise associated with rocket launches is jet noise. The nature of the noise may be described as intense, relatively short, composed predominantly of low frequencies and infrequent.

Research on the effect of noise on man has yielded criteria for noise levels and durations which man can generally tolerate. Table 5 shows a set of consensus tolerance limits. The Damage Risk Values are thresholds beyond which hearing damage might occur. The peak sound pressure levels observed during a number of Atlas launches are given in Table 6.(2) Comparing these values to the damage risk values, it appears that, within a 1-mile radius, intensity levels may be reached which could cause permanent damage or temporary hearing loss if ear protection or shelter is not provided. Between radii of 1 and 2 miles, intensity levels may also be sufficient to cause temporary hearing loss and severe discomfort if ear protection is not provided. Annoying intensity levels may extend beyond 2 miles. The nearest access by uncontrolled personnel (Press Site 2) is slightly more than 2 miles from the launch pad. Sound pressure levels at the boundaries of the launch site will be less than 108 db.

Structural damage is possible with high-intensity noise composed, predominantly, of low frequencies. At a distance of 5000 ft, sound pressure levels resulting from Atlas launches have been measured as about 120 db for frequencies lower than 37 Hz.(2) Only resistant structures are located within this short distance from the launch pad.

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(1) Information obtained from R. M. Anschutz, Pratt and Whitney Aircraft, West Palm Beach, Florida, November 9, 1971.

(2) J. H. Cole, R. G. Powell, and H. K. Hill, "Acoustic Noise and Vibration Studies at Cape Canaveral Missile Test Annex, Atlantic Missile Range, Volume 1, Acoustic Noise", Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, T.R.61-608(1), 1962, AD296852.

TABLE 4. COMPARISON OF ANNUAL EMISSIONS INTO THE LOWER ATMOSPHERE FROM OTHER SOURCES WITH TOTAL EMISSIONS FROM THE PIONEER F AND G LAUNCH VEHICLES

Source	Emission, 10^6 lb	
	CO	HCl
Pioneer F and G Missions (2 launches)	0.233	0.001
Automobiles (per year)	124,000[a]	9[b]
Power Plants (per year)	200[a]	1340[b]
Trash Incineration (per year)	15,200[a]	400[b]
Jet Aircraft (per year)	600[a]	--

(a) For 1966. Sources: APCO/DAWED, DPCE and APCO(NAPCA) reports.
(b) Estimates from Gerstle and Devitt, "Chlorine and Hydrogen Chloride Emissions and Their Control", Paper No. 71-25, Air Pollution Control Association, 1971.

TABLE 5. NOISE LEVELS AND DAMAGE RISK AND ANNOYANCE[1,2]

Damage Risk Values (in db)	Annoyance Threshold	Damage to Ground Structures Threshold
130 (10 seconds tolerance)	90 db(A)	130 db (frequencies lower than 37 Hz)
125 (30 seconds tolerance)		
120 (60 seconds tolerance)		

TABLE 6. PEAK SOUND PRESSURE LEVELS OBSERVED DURING ATLAS LAUNCHES

Distance from Launch Pad (ft)	Peak Overall Sound Pressure Level (in db)
8,000	124
12,000	118
28,000	108
50,000	100

(1) Kryter, K. E., The Effects of Noise on Man, Academic Press, New York; 1970.

(2) Regier, A. A., Mayes, W. H., and Edge, P. J., Jr., "Noise Problems Associated With Launching Large Space Vehicles", Sound, 6, 7-12 Space; 1962.

It is clear from these data that booster noise does not have a significant impact on the environment. No uncontrolled areas are close enough to the launch pad for any significant effects to result from exposure of the public or uncontrolled-area structures to these noise levels.

Maximum noise levels expected at Press Site 2 correspond closely to that which would be experienced from a four-engine jet aircraft 500 ft overhead. Unmuffled motorcycles, construction noises (compressors and hammers), and some rock and roll bands, closely approach this noise level. This noise level is exceeded by pneumatic riviters and chippers in close proximity and within a boiler shop at maximum noise levels.

Effects of Spent Stages and Jettisoned Hardware. The environmental effect of spent stages and jettisoned hardware from normal launches of Pioneer F and G could potentially take the form of:

- Hazards to life and property from direct physical impact.
- Effects on air or water quality by contamination with residual propellants or other materials.

Spent stages and hardware which are jettisoned before orbit is attained impact in the Atlantic Ocean as shown in Figure 2. The potential hazards presented by such jettisoned items are exhaustively reviewed as a part of the mission planning. Trajectories, sequences, etc., may be modified as needed to control impact locations. No significant hazard to the public is permitted. The potential effect of such jettisoned hardware on water quality is discussed in this Statement under that heading. No effect on air quality is known to result from jettisoned hardware.

In the Pioneer F and G missions, the Centaur stage is jettisoned in a geocentric orbit. Over a period of years, the orbit will decay and the Centaur will reenter the Earth's atmosphere. The heating and dynamic forces accompanying reentry cause the Centaur to break up into fragments and to partially melt and ablate into fine particles. Any residual fluids remaining in the Centaur will be dispersed into the upper atmosphere. The hazard presented by fragments of significant size which reach the ground has been examined. It was concluded that the impact hazard presented by reentering stages was a very small fraction of that presented by natural meteorites, which itself is negligible.

Effects on Water Quality. A normal launch and flight will result in the down range impact of Atlas stages and hardware with the following materials which may have some effect on water quality:

Hardware	-	Heavy metal ions (corrosion products) and miscellaneous compounds
Liquid Propellant	-	RP-1.

Jettisoned or reentered hardware will corrode and thus contribute various metal ions to the environment. The rate of corrosion is slow in comparison with the mixing and dilution rate expected in a marine environment, and, hence, toxic concentrations of heavy metal ions will not be produced. The miscellaneous materials (e.g., battery electrolyte, hydraulic fluid) are present in such small quantities that, at worst, only extremely localized and temporary effects would be expected.

Primary concern for water quality relates to possible release of RP-1 fuel which is only partially miscible with rwater. RP-1, if released, may float on the surface of the water or be emulsified by wave and wind action. Liquid oxygen and liquid hydrogen do not pose any threat to water quality.

RP-1, as a kerosene-type material, should have very little toxicity for fish except possibly when emulsified by agitation with water. Reference 1 states that such petroleum products appear to have no soluble poisonous substances. Other information, also from Reference 1, indicates that kerosene applied as an insecticide at a rate of 25 gallons per acre had no effect on freshwater fish but that agitated solutions of jet aviation fuel were lethal to fingerling salmon at concentrations of 500 mg/l. A maximum allowable concentration (MAC) for trout exposed to gasoline dispersed in water is reported as 40 mg/l.

It is also reported that "oil" destroys plankton, especially diatoms, and diminishes aeration at the surface.(1) However, the similarity of "oil" and kerosene-type materials in terms of these effects is not clear and, evidently, has not been investigated. The low concentrations of aromatics and olefins in RP-1 suggest a relatively benign "oil" as compared to the crudes and heavy distillates usually involved in oil spill incidents.

The ocean areas where impact will occur (see Figure 2) are characterized as tropical oceans.(2) Also, the southeast coast of Florida in the vicinity of the Eastern Test Range is characterized as a tropical blue-water coast. The Florida current prevents the continental runoff from establishing much of a green-water zone, and blue-water conditions may reach to within three kilometers of the beach.

Tropical oceans and blue-water coasts are distinguished by extremely clear water. The result is an euphotic zone which may extend well below 100 meters in contrast to green coastal waters where it is usually no deeper than 30 to 40 meters.

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(1) J. E. McKee and H. W. Wolf, "Water Quality Criteria", The Resources Agency of California, State Water Quality Control Board, Publication No. 3-A, 1963.

(2) W. E. Odum, and J. J. Walsh, "Tropical Blue-Water Coasts", <u>Coastal Ecological System of the U. S.</u> (H. T. Odum, B. J. Lopeland, and E. A. McMahan (Editors)), Institute of Marine Sciences, University of North Carolina, 1969, p. 526-545.

Because the solar radiation remains more or less constant throughout the year in the tropics, the temperature of the surface water shows little fluctuation. The stable input of solar energy creates a remarkably deep isothermal layer over a permanent thermocline. The thermocline is rarely destroyed and its depth depends upon the velocity and duration of surface winds.

The permanency of the tropical thermocline effectively prevents vertical mixing between the warm surface layer and the deep cooler waters. For this reason, there is little seasonal recharging of nutrients in the surface water such as occurs at higher latitudes. As a result, tropical surface waters are characterized by extremely low nutrient levels.

The communities of phytoplankton and animals associated with surface waters of blue-water coasts are typically pelagic. Perhaps, the most conspicuous feature of tropical blue-water communities is the great number of species present as compared with waters at higher latitudes.

The RP-1 residuals in the Atlas stages (see Table 1) are small and, using the methods of Blokker(1), it can be predicted that a surface film covering less than 1/10 square mile will be produced on water. For a highly volatile material such as gasoline, this film would not persist longer than about 4 hours. RP-1 is less volatile than gasoline, but other modes of disappearance also exist. Persistant effects are not expected.

Since tropical surface waters are not highly productive and contain only a few fish of a great number of species, effects of RP-1 and other materials on the ocean ecology are judged to be minimal.

It is possible, under some circumstances, for the deluge water used to cool the flame deflector during launch to be contaminated with unburned fuel. The deluge water is collected in a holding pond where the water is visually examined for any hydrocarbon sheen. If hydrocarbons are determined to be present, the surface of the pond, approximately 50 by 100 feet, is skimmed to remove them. After skimming, the water is released to a drainage canal emptying into the Banana River.(2)

<u>Solid Waste</u>. The manufacture, testing, and launch of the launch vehicle and spacecraft for the Pioneer F/G missions consumes steel, aluminum, paper, etc. Some of these materials become scrap and, thus, potentially contribute to the solid waste generated by the nation. The quantity of such scrap is probably not grossly different from that generated by the employment of an equal number of people in other industrial activities. In general, the scrap produced is of relatively high value and, thus, is usually recovered.

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(1) P. C. Blokker, "Spreading and Evaporation of Petroleum Products on Water", International Harbour Congress, 4th, Verslageboek, Computerendu (Proceedings, Tagungsbuch), Antwerp, 1964, p. 911-919.

(2) Information provided by R. L. Thompson, NASA, Kennedy Space Center, Florida, November 5, 1971.

Pesticides. Pesticides are not required in the manufacture, testing, and launch of space vehicles. Incidental usage of pesticides for public health purposes is covered by the environmental statements of the appropriate facilities involved.

Abnormal Launches, Aborted Flights, and Accidents

Only one on-pad failure (Atlas/Centaur 5) has occurred in 138 launches related to NASA automated missions in the period of 1965 through May, 1971. Approximately 90% of the NASA automated space launches have been successful. Of the 138 launches mentioned above, two Delta launches (and no Atlas/Centaur launches) resulted in failures during the early phase of flight when significant quantities of propellant remained unused. Range safety precautions are such that areas subjected to possible impact of vehicles from aborted flights are carefully studied and controlled. In the event of an in-flight failure in the early stages of flight, the vehicle destruct system would rupture the propellant tanks and disperse the propellants into the air. The propellants then normally ignite and burn.

Effects on Air Quality. In the event of an accident on the pad or at low altitude in which the rocket fuel would be lost, unburned hydrocarbons would be of interest. Estimates based on the work by Cramer, et al.(1) for larger rockets indicate that such accidents involving Atlas/Centaur would result in concentrations too low to have significant air pollution effects.

With the on-pad or low-level burning of Atlas propellants, some CO would be produced, but probably much less than during normal rocket combustion because of the presence of atmospheric oxygen. Because computed and measured ambient CO levels for normal launches and ground-level engine tests are much lower than allowable concentrations, no adverse effects on air quality should be expected for accidents resulting in low-level burning of RP-1 fuel.

Effects on Water Quality. Concern with on-pad spills for the Atlas/Centaur relates to the necessity of preventing the discharge of RP-1 to the environment. The launch pad is so constructed that any propellant spills will drain to a holding pond. Any spilled propellant is disposed of in a non-polluting manner in an installation operated by the USAF. On-pad vehicle failures would normally be expected to result in a fire that consumed most or all of the propellants. Any unconsumed propellant would be disposed of in the same way as a spill.

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(1) H. E. Cramer, R. K. Dumbould, F. A. Record, and R. N. Swanson, "Titan IIID Toxicity Study", Report No. TR-70-3-A, GCA Corporation, June, 1970.

In event of an accident or intentional vehicle destruct, it is possible that some propellant may reach the ocean surface. If the destruct system should fail to operate, the vehicle might impact intact and release the entire quantity of remaining propellant into the ocean. Such an extreme event is not considered likely since it would require the simultaneous early failure of the vehicle and failure (never observed) of the vehicle destruct system. Consequently, minimal significance is attached to such an event.

The early abort of an Atlas which resulted in the entire load of RP-1 being released into the ocean would result in a surface film covering a maximum of four square miles.(1) Evaporation should be rapid due to the thinness of the film. Due to the small area involved and the fleeting nature of the phenomena, no significant environmental effect is expected. As discussed previously, the probability of such an event is regarded as very low.

Effects of Noise. No significant differences in comparison with normal launches are expected.

Effects of Spent Stages and Jettisoned Hardware. Except as previously noted in this section, in regard to air and water quality, no differences in comparison with normal launches are expected.

Spacecraft

Description of Spacecraft and Mission

The Pioneer spacecraft weighs about 560 pounds and essentially is two thermally-controlled equipment compartments, one hexagonally shaped and containing spacecraft equipment and the other an appendage containing scientific instruments. Forward of the equipment compartments is a 9-foot diameter, parabolic reflector for the high gain medium gain antenna and the feed for the high gain reflector. Electric power is supplied by 4 radioisotope thermoelectric generators mounted in pairs on two radially deployable trusses. The generators are in a stowed position for launch, next to the equipment compartment and under the reflector of the high gain antenna. In the deployed position, the generators extend well

(1) P. C. Blokker, "Spreading and Evaporation of Petroleum Products on Water," International Harbour Congress, 4th, Verslagboek, Comterendu (Proceedings, Tagungsbuch), Antwerp, 1964, p. 911-919.

beyond the perimeter of the reflector to reduce the radiation environment within the equipment compartments and reduce their magnetic influence at the magnetometer. The magnetometer is located on the end of a long folding boom which, in the deployed condition, extends radially from the instrument side of the equipment compartment.

Eleven scientific instruments are carried and viewing aperatures are provided in the equipment compartments as required. Mounts external to the equipment compartment are provided for the meteoroid and asteroid instrumentation.

The spacecraft is spin-stabilized with a spin rate near 5 rpm. Despin from the initial spin rate imparted by the launch vehicle (about 60 rpm) and deployment of the RTG's and magnetometer occur automatically on separation of the spacecraft from the third stage motor. The spin axis will point to the Earth so that the radiation beam of the high gain antenna will illuminate the Earth.

Typical trajectories during the favorable launch opportunities take between 600 and 900 days to reach the vicinity of Jupiter. Nearly all this time is spent in the interplanetary, solar-wind environment; the spacecraft will depart from all influences of the earth magnetosphere several hours after launch and will not penetrate the Jovian magnetopause until several days before periapsis (closest approach to Jupiter).

The spacecraft will be directed to perform one or more velocity corrections to compensate for launch vehicle injection errors and to place the spacecraft on a trajectory to the desired target point near Jupiter. It is planned that the first of these maneuvers will be performed within the first 10 days and the second, if necessary, about 30 days after launch.

During the long interplanetary cruise phase, the characteristics of particles, fields and zodiacal light will be measured by the scientific instruments and transmitted to Earth.

About one hundred thirty days after launch, the spacecraft will be 2 AU from the Sun, and for the next 200 days will pass through the asteroid belt. Here measurements will be conducted which will increase knowledge of the small particle population of the region; here, also, may exist a danger of unknown severity to the spacecraft from possible impact by larger size particles.

At Jupiter, Pioneer will pass the bow shock about 90 hours before periapsis and the magnetopause at 50 hours. It will penetrate the radiation belts to a closest approach about two Jovian radii above the surface. The spacecraft will then swing around the dark side of the planet and start its trip on out of the solar system. By about three days after periapsis Pioneer will be out of the main region of Jupiter's dominance and essentially back into interplanetary space. At Jupiter the scientific objectives are to take pictures, especially near the terminator and to study the heat balance, atmospheric composition, the ionosphere, and the strong radiation belts and magnetic fields. From the standpoint of possible effects on the environment, a Pioneer spacecraft can be viewed as follows:

Electronic Boxes	185 lbs.
Structure and Mechanical Devices	295 lbs.
Hydrazine Propellant	69 lbs.
Radioisotope Fuel Capsules	30 lbs.
TOTAL	560 lbs.

The Structure and Mechanical Devices includes the aluminum framework and honeycomb panels of the equipment compartment, the antenna, outer radioisotope thermoelectric generator (RTG) housings, etc. Effects of the first three items above are identical to those discussed under launch vehicle and will not be repeated. The fourth, Fuel Capsules, will be considered in more detail along with the small radioisotope heaters used on Pioneer F/G.

RTG's

The Pioneer spacecraft derives its electrical energy from four SNAP 19 radioisotope thermoelectric generators. Each hermetically sealed generator has within it a heat source consisting of a reentry heat shield and a fuel capsule. Each fuel capsule is a multi-layered container containing seventeen plutonia molybdenum cermet discs comprising 20,000 curies of Pu-238. The strength member is 0.09 inch thick T-111 tantalum with 8% tungsten and 2% hafnium and is clad with 0.02 inch of platinum 20% rhodium. The purpose of the strength member is to provide resistance to mechanical loads. An 0.02 inch thick tantalum 10% tungsten liner is within the strength member. The liner serves as an assembly tool which can be readily decontaminated during the manufacturing process. An 0.005 inch thick molybdenum--46% rhenium inner liner is around the fuel. Its purpose is to arrest solid-state transport of oxygen from the fuel to the strength member.

The plutonia molybdenum cermet fuel form was especially developed to minimize the creation of respirable PuO_2 particles in potential accident environments such as blast, fire, impact, and reentry. It is made by coating plutonia particles, 105 to 250 microns in diameter, with about 3 microns of molybdenum. The coated material is then vacuum hot pressed to form a disc. The composition of the disc is 82.5 weight per cent PuO_2 and 17.5 weight per cent molybdenum.

$^{238}PuO_2$ is characterized by 5.4 Mev alpha particles, 17 Kev X-rays, and 0.5 - 4.4 Mev neutrons. The dose rate from the side of a generator is about 10 millirem per hour at one meter. There is no possibility of a nuclear criticality incident since the total quantity of fuel is less than a critical mass even in the most reactive geometry.

Three cylindrical sleeves of pyrolytic graphite and a POCO graphite hexagonal heat shield surround the fuel capsule and serve as reentry protection.

Radioisotope Heaters

Twelve radioisotope heaters are used on the Pioneer spacecraft to maintain adequate temperature control for propellants and instrumentation. Each heater contains one thermal watt (30 curies) of PuO_2 in the form of Plutonia Molybdenum Cermet (PMC). The PMC is contained in a fuel capsule consisting of an 0.02 inch Ta-10W liner which is encased in an 0.04 inch T-111 strength member. The strength member is sealed within an 0.01 inch Pt-20Rh clad. The fuel capsule is in a reentry heat shield consisting of pyrolytic and POCO graphites which will protect the capsule should it be subjected to a reentry heat pulse.

Detailed safety studies have led to the conclusion that it is virtually impossible to have fuel releases from the heaters and that they do not impose any risk to people and the environment when considered with the probabilities and consequences of potential accidents.

Normal Mission

The nominal mission will result in the launching of a Pioneer spacecraft on a trajectory which will leave our solar sytem and never return. Thus, the normal mission poses no risk to man or to man's earth environment.

During the pre-launch and launch operations, operational personnel may be exposed to direct gamma and neutron radiation. The exposure to these personnel will be minimized by the use of minor shielding and limiting work times around the generators. This will limit the exposures to individuals such that they will not exceed those limits set forth by the Federal Radiation Council, National Committee for Radiation Protection and the International Committee on Radiation Protection.

Abnormal Mission

The probability of achieving a normal mission is 0.949. Of the abnormal missions a number will escape earth without any additional ground control. In addition, a number can be placed in orbits with lifetimes before reentry in excess of 1000 years by which time radiation levels are negligible. The number for these two groups is 0.025, so that the probability that a radioactive system will not return to earth is 0.974.

Of the number that do return (0.026), 0.002 are predicted to occur near the launch pad, 0.018 in the ascent phase resulting in ocean impact, and 0.006 in orbits less than 1000 years. Of the 0.006 above, 75% of those returning to earth or 0.0045 will impact in the oceans.

Thus, the most probable accident fate is that the heat sources will impact in the ocean. In the event the impact occurs early in the flight, "pingers" (water actuated hydrobeacons) have been placed on the vehicle near the spacecraft to assist in the location of the nuclear systems and their return to radiological control if they are at recoverable depths.

The consequences of a capsule impacting in the ocean where recovery is not possible have been analyzed. The capsule materials are insoluble as is the fuel form, and it would be expected that dissolution would probably take place by diffusion of the water into the capsule and some dissolution followed by subsequent diffusion of the dissolved plutonium out of the capsule. Such a series of events would take hundreds of years by which time the activity would have substantially decayed away.

Analyses, however, have been conducted which assumed that the entire capsule fuel loading was exposed to the ocean environment. With an experimentally established dissolution rate of 0.03 μg $^{238}Pu/g$ of PMC/day, even if a man were to obtain his entire annual protein diet from fish (72 kg) grown in the contaminated area, the calculated maximum annual intake of ^{238}Pu would be 0.002 μci. This is to be compared to a maximum permissible intake of 4 μci/year recommended by the ICRP. In summary, using the most recent data on concentration factors, the conclusion drawn from the analyses is that the amount of Pu-238 which can possibly find its way into the marine biota on the human diet would be well within established limits.

The effects of radiation dosimetry on marine organisms has also been analyzed. The highest Pu concentration factor that has been observed for marine animals was that for zooplankton (2600) reported by Pillai, et. al. If we take the maximum seawater concentration of Pu-238 predicted by the Carter-Okubo shear diffusion model for an 0.012 ci/day dissolution rate, and assume that plankton come to equilibrium with water having a Pu-238 concentration of 2.4×10^{-9} $\mu ci/cm^3$, the concentration of Pu-238 in the plankton would be 6×10^{-6} $\mu ci/g$ or 6000 pci/kg. This activity concentration delivers approximately 600 mrads/yr of alpha radiation to the plankton, which is some 15 times the estimated dose rate derived by consideration of cosmic rays and ^{40}K in the seawater. The effects of such dose rates cannot be predicted accurately, but the biomass of plankton involved would be very small and no population effects would be expected.

In the event an abort occurs with impact in the launch area the capsule is expected to survive with no release of the radioactive material. Following recovery, the capsule will be returned to the AEC for reprocessing and reuse of the fuel.

An extensive safety testing program was conducted to determine the response of the heat source when exposed to the most severe abort environments. The results of these tests, when combined with the studies of the launch abort environments and their probabilities, lead to the conclusion that the probability of any fuel being released is one or two chances in a million, and then only a small quantity of respirable material would be available. It is unlikely that anyone would be exposed to Pu-238 above the 0.0005 μci level established for the general public.

Despite the extremely low failure probability, contingency plans have been formulated to further reduce the possibility of individuals being exposed to radioactive material. To implement these plans a Radiological Control Center will be in operation during the prelaunch, launch, and ascent phases of the missions. The Center will be manned by safety and medical representatives from NASA/KSC, DoD/Air Force Eastern Test Range, AEC and EPA and will be able to : rapidly determine if a release of radioactive material has occured; rapidly assess the extent of radiological dispersion, if any; protect people; decontaminate; and remove radioactive material.

ALTERNATIVES

The Pioneer F and G missions have been designed with consideration of the scientific return from the spacecraft, the available launch vehicles, and the total cost of performing the missions. The resulting missions are effectively "minimal" missions.

Launch Vehicle

The launch vehicle for the Pioneer F and G missions is the smallest vehicle in the family of United States launch vehicles capable of delivering a useful mass to the vicinity of Jupiter. Consequently, no smaller available vehicle can be considered as an alternative to the Atlas/Centaur/TE-364-4. The choice of a significantly larger vehicle would be wasteful of vehicle capability and would increase the cost of the mission. One vehicle comparable to the Atlas/Centaur/TE-364-4 could be considered--the Titan IIIB/Centaur/TE-364-4. However, the Centaur has not been integrated with the Titan IIIB, and no launch facilities for this configuration exist at ETR. Vehicle integration and the preparation of a launch facility would probably cost \$10-20 million. In terms of the environmental effects, the Atlas is probably more innocuous than the Titan, although neither vehicle appears to offer any significant threat to the environment.

The only vehicle concept known that would be substantially more benign than the Atlas/Centaur/TE-364-4 would be an all liquid oxygen-liquid hydrogen vehicle. Development of a liquid oxygen-liquid hydrogen booster to replace the Atlas could cost more than $500 million and require about five years of development effort.

Spacecraft

A study of alternatives concluded that nuclear power is the only possible source of power that can be used on the Pioneer spacecraft.

The considerations dictating the use of nuclear power in the Pioneer spacecraft were (1) passage through the asteroid belt (low-cross-section), (2) operation in a Jupiter solar flux some 25 times less than that in earth orbit, (3) operation in the intense radiation field of Jupiter, (4) a requirement that the power supply operate at least 645 to 795 days after launch at Jupiter encounter and if possible several years after Jupiter encounter, and (5) light weight and maximum reliability. (Nuclear power meets requirements (1) through (5)).

Solar cells cannot meet any of the requirements stated above. Batteries and fuel cells cannot meet requirements (3) through (5). Thus, the alternatives are obviously nuclear power or abandonment of the Pioneer mission and other future interplanetary missions.

THE RELATIONSHIP BETWEEN THE LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The Pioneer F and G missions represent passive payloads which in themselves have no adverse environmental impact aside from that associated with items in space, reentry items, and the launch process. Reentry items and the launch process represent minor transient effects while items remaining permanently in outer space have no impact on the Earth and its atmosphere.

It is expected that local short-term use of the environment in this program will provide cumulative and long-term beneficial effects by virtue of the knowledge which will accrue from the scientific experiments. Measurements obtained by the instruments on Pioneer F and G will supplement and extend those from Pioneers 6, 7, 8, and 9. Pioneer 6-9 spacecraft are providing a basic understanding of the interplanetary media (plasma, magnetic fields, energetic particles, dust and waves) near the Earth's orbit and the solar-interplanetary and interplanetary-terrestrial relationships. The Pioneer F and G missions will permit the first investigation of the interplanetary medium (fields and particles, radial gradient, structure, etc) beyond Mars, asteroid belt hazard, Jupiter interaction with the interplanetary medium, Jupiter radiation belts and the Jovian atmosphere and thermal balance. A comparison of the Earth and Jupiter phenomena might provide improved understanding of both planets.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The material which make up a launch vehicle and spacecraft as it sits on the pad ready for launching are largely irretrievable once the launch process is initiated. However, they are relatively easily replaced and, in general, are replaceable from domestic resources with relatively insignificant expenditure of manpower and energy.

By far the largest weight of materials making up a launch vehicle are the propellants. These have previously been enumerated and defined; they are common chemicals, petroleum-derived hydrocarbons, and liquified atmospheric gases. Resources and energy required for their production are nominal and insignificant in comparison with, for example, the resources and energy required to produce 1 million barrels of jet fuel per week, the current production rate, for private, commercial, and military jet aircraft.

The Atlas/Centaur vehicle requires about 214,000 scf of helium from test through launch.(1) The estimated amount of recoverable helium is about 180 billion cubic feet with a current annual usage rate of about 1 billion cubic feet.(2) At current rates, use for all NASA purposes approximates 120 million cubic feet per year.(3) The actual usage attributable to the Pioneer F and G launches is thus about 0.4%of the NASA annual consumption, 0.04% of the national annual consumption, and 0.0002% of the recoverable reserves.

After propellants, the next largest amounts of materials are steel and aluminum. Other materials include plastics and glass, as well as other metals such as nickel, chromium, titanium, lead, zinc, copper, etc. Small amounts of silver, gold and platinum are typically used. The quantities of materials of various kinds which are utilized are insignificant in comparison with those used in one year of production (10,000,000) of automobiles, for example.* Significant amounts of those materials used for autombile manufacture are not returned for recycle and, thus, could be termed an irreversible and irretrievable commitment of resources.

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(1) Estimate provided by R. Schmidt, NASA, Code SV, November 12, 1971.

(2) Monograph of Liquid Helium Technology, National Bureau of Standards, 1968.

(3) Estimate provided by W. R. Harwood, NASA, Code BXE, October 5, 1971.

* A single Pioneer launch involves a total weight of hardware equivalent to about 6 automobiles.

COMMENTS ON PIONEER ENVIRONMENTAL STATEMENT

The draft version of the statement was prepared by Pioneer Program personnel within NASA and the AEC and was reviewed by the appropriate elements of these organizations before publication of the draft.

Comments on the draft version were received from EPA and the Division of Environmental Protection of the Commonwealth of Massachusetts (See Attachments). These comments pertained to the wording of the draft statement and not to the Pioneer Program itself. This final statement includes the modifications suggested in the comments.

<u>SUMMARY</u>

ENVIRONMENTAL STATEMENT

FOR THE

PIONEER PROGRAM

( ) Draft (X) Final

<u>Responsible Federal Agency</u>: National Aeronautics and Space Administration (NASA), Office of Space Science, Planetary Programs

1. (X) Administrative Action ( ) Legislative Action

2. The Pioneer F and G spacecraft are the sixth and seventh of an ongoing series of planetary and interplanetary space exploration missions and which will be launched by an Atlas Centaur rocket from Cape Kennedy, Florida to the vicinity of the planet Jupiter in 1972 and 1973.

3. There are insignificant adverse environmental effects from the products of the launch vehicle and none from the radioisotope generators on the spacecraft.

4. No alternate method for performing these missions is available at this time.

5. Comments requested from: CEQ, EPA. Reviewed by the AEC.

6. Draft statement to CEQ on: August 1971

7. Comments received from EPA, and the Division of Environmental Protection, The Commonwealth of Massachusetts.

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF THE ADMINISTRATOR

OCT 26 1971

D-NAS-12001-00

Mr. Ralph E. Cushman
Special Assistant
Office of Administration
National Aeronautics and Space
Administration
Washington, D.C. 20546

Dear Mr. Cushman:

This is in response to your letter of August 24, 1971, requesting comments on the "Draft Environmental Statement for Pioneer F/G Program, August 1971." We have studied the draft impact statement and our detailed comments are enclosed.

In general, the statement does not include sufficient detailed information on flight procedures, design and operational characteristics of equipment to be employed, possible accidents and emergency contingency plans, to permit a complete environmental assessment of the program.

If you have any questions on our comments or related matters, please contact Mr. Jack Anderson of this office.

Sincerely,

George Marienthal

George Marienthal
Acting Director
Office of Federal Activities

Enclosure

AA 10/29/71

B-561

Detailed Comments on the Draft Environmental (Impact) Statement for Pioneer F/G Program

The draft impact statement for the F/G segment of the Pioneer Program does not, in our opinion, support the contention that there will be "... no adverse environmental effects from either the products of the launch vehicle or from the radioisotope generators on the spacecraft." This general conclusion must be supported by an appropriate analysis of the possible environmental effect of every important aspect of the project. To this end, all relevant data, information, outlines of research studies, with references and other applicable technical facts should be outlined in the draft environmental statement. The inclusion of this material would permit a reasonable environmental assessment of the F/G project on the basis of the content of the draft statement alone. Not only would this facilitate the review by EPA and other Federal agencies, but would greatly strengthen the statement and enhance its usefulness as a public document.

Possible adverse environmental effects could arise, in general, either from routine operations during launch or from nonroutine situations involving launch aborts or vehicle accidents. Some possibilities are: contamination of the upper atmosphere by exhaust emissions; the dumping of unburned fuel and other chemicals or radioactive materials into surface waters; or the spilling of radioactive fuel from RTG units into the earth environment. These possibilities constitute the most probable source of pollution and human health hazard.

In our opinion, dismissing the consideration of alternatives, reasoning that "... no adverse impact of the present program on the environment is expected," is not realistic. While no alternative to the total F/G project other than complete abandonment may exist, alternatives to the operational methods and procedures, as well as specific equipment or hardware employed do exist and the environmental advantages or disadvantages of each should be thoroughly explored in the draft environmental impact statement.

<u>Routine Operation</u>

I. The effect of gaseous emissions from the launch vehicle exhaust and any routine venting operations on the atmosphere should be addressed in the draft impact statement. The statement should provide information on:

(1) The quantities and types of fuels employed as well as the composition and quantity of the exhaust gases.

(2) Types, quantities, and chemical nature of all substances, other than vehicle exhaust, routinely vented.

(3) The flight paths indicating the distribution of emissions along trajectory.

(4) The meteorological nature of the regions of the atmosphere likely to be affected, giving the physical composition, wind structure, and vertical/horizontal dispersional characteristics.

The possible environmental effects of the contaminants should be discussed in detail citing the general conclusions of any pertinent studies which have been done.

II. The draft statement should discuss the possibility of contamination of groundwater during the brief period when the launch vehicle is on or near the launch pad. One possibility might be the effect of contaminated exhaust deflector cooling water on local water quality.

Nonroutine Situations

The draft statement should be expanded to include a complete discussion of the various types of credible mission accidents and an estimate of the probability of occurrence of each. The discussion should be directed toward an assessment of the possible adverse environmental consequences inherent in such accidents and how these consequences vary depending on where in the flight procedures they occur (i.e., during the launch, at high altitudes, or during near-earth operations).

Two possibilities which deserve particular attention are:

I. Contamination of surface water and the lower atmosphere by the intentional dumping or accidental spillage of unburned jet fuel accompanying a mission abort or launch accident. The statement should include information concerning:

(1) The types and quantities of fuels likely to be involved;

(2) The probable environmental fate of such fuels citing hydrologic, oceanographic, or meteorological data where appropriate;

(3) The nature of the chemical reactions and properties of resulting chemical compounds produced when fuels contact either salt or fresh water, particularly as these compounds affect water quality and marine life;

(4) The bodies of water or regions of the atmosphere likely to be affected.

A similar discussion should be included on any other nonradioactive materials, chemicals, or toxic substances which are likely to be dispersed by accident or design. Only those that are on board the space probe or the launch vehicle in sufficient quantities to pose an environmental hazard need be considered.

II. Radiological contamination of air or surface water by the accidental release of radioactive materials which could occur as a result of the rupture of any vessel containing radioisotopes. Any type of equipment which contains significant quantities of radioactive material, whether it be a nuclear generator or experimental device, could present a hazard. The environmental impact statement should provide details on the following:

(1) Types and nature of all equipment to be used in the Pioneer F/G program containing any type of radioactive material and the degree to which this equipment approaches design objectives.

Same comment as on shuttle draft.

(2) The source terms for radioactive material (i.e., the types and quantities of isotopes; physical state(s) of materials(s); modes, energies, and half-lives associated with radioactive decay). Also, the total radioactive emission level in curies of each isotope should be stated.

(3) The probable environmental fate of any radioactive material released based on:

(a) Physical form of material(s) released as a function of the type of accident.

(b) Amounts of material involved.

(c) Point of release (i.e., geographical location and altitude).

(d) The meteorological or hydrological characteristics of the region.

(4) Estimated direct exposures and indirect exposure through food chains both on and off-site under "average" and "worst case" meteorological conditions. Discussion should include a complete description of monitoring, facilities, operational plans, personnel and their responsibilities; system performance capabilities and limitations.

(5) Accident contingency and radiological safety plans, including a description of the organization, operation, objectives, and the response capabilities of all involved health agencies in addition to decontamination procedures to be employed in the event of a radioisotope fuel spill.

General Comments

The following general comments should also be considered in the preparation of the Final Statement.

(1) All technical and scientific studies cited as giving supportive evidence in the statement should be available to any interested public or governmental organization or individual.

(2) The statement refers to both the F and G missions of the overall Pioneer program. The inclusion of both of these missions in one statement is acceptable only if no modifications occur in the details of the G mission which could change the environmental impact from that described in the final F statement. Technical changes such as the use of different launch vehicles or a different fuel encapsulation design are examples of modifications which may change the accident probabilities or the resultant radiation hazard and therefore could materially affect the mission's environmental impact. A critical determination of the net effect of all changes should be made in the interim between the launch of the F mission and the G mission and, if deemed appropriate, an amended, supplemented, or completely new statement should be submitted.

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(3) Additional distribution of both the draft and final statements is desirable and should include the Departments of Defense, State, Agriculture, and Interior, and the State of Florida.

(4) The discussion of alternatives should be broadened to include the selection of the RTG power source over other sources. The results of any parametric studies done in this should be summarized and referenced.

(5) The final statement should discuss other nonradiological aspects of launch phase and reentry accidents such as fires.

DEPARTMENT OF THE ATTORNEY GENERAL
STATE HOUSE • BOSTON 02133

ROBERT H. QUINN
ATTORNEY GENERAL

Action Copy to B
Info Copy to AA, PA
A-36712

September 24, 1971

Rec'd in NASA 9/29/71

Suspense Date none
Prepare Reply for
Signature of none

Homer E. Newell, Associate Administrator
National Aeronautics and Space Administration
Washington, D. C.

Dear Mr. Newell:

Thank you for sending me, by way of Mr. Cushman, a copy of the N.A.S.A. Draft Environmental Impact Statement for the Pioneer F/G Program. I would like to make some comments on the draft. I believe such comments are appropriate and in accordance with section 102(2)(c) of the National Environmental Policy Act which refers to "...the comments and views of the appropriate Federal, State and local agencies, which are authorized to develop and enforce environmental standards..." Any state agency charged with protecting the environment has standing to make comments relative to federal agency action which is within the broad statements of policy in sections 2, 101(a) and 102(2)(e) of the National Environmental Policy Act.

Briefly, my comments are follows:

1. Statements entitled "2. <u>Environmental Impact</u>" and "3. <u>Adverse Environmental Effects</u>" are inconsistent. For instance, there is noise associated with any vehicle launch. This noise is an "adverse environmental effect", be it large or small, which must be considered and balanced against the desirable effects along with other adverse effects. If there are indeed no adverse effects, a statement to that effect should be supported by data.

2. The draft statement omits any discussion of possible adverse effects outside the earth and its atmosphere. I believe that the reference in Section 101(a) (N.E.P.A.) to "future generations of Americans" as well as the broad policy statements demands that such effects be considered carefully and that the final statement include relevant data and documents. Such effects might include possible pollution of the atmospheres of other planets, effects of emissions in space, littering of space, or the possibility of crashes.

3. There are certainty some adverse effects so alternate programs should be considered. The environmental impact statement should disclose a careful balancing of environmental detriment against program benefit and should lead to a decision based on that balancing. (See Calvert Cliffs v. A.E.C. 2 ERC 1779 (1971)). I believe that the final statement on the Pioneer Program should contain detailed data and studies to support, as much as possible, the decision made and to reveal the basis for the decision to the public.

Thank you again for your past cooperation. I sincerely hope my comments will be of some assistance to you in preparing the final environmental impact statement.

Sincerely,

Harley F. Laing

HARLEY F. LAING
Legal Assistant
Division of Environmental
Protection

HFL/jms

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